Power Optics of Magnification

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PURE OPTICS

Strategy | Operations | Education

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Reference

New Pure Optics Third Ed.

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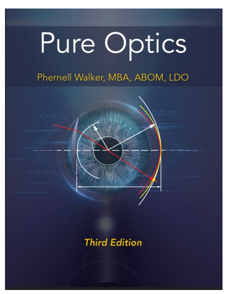

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Image Size to Object Size

- Magnification – increased image size compared to object size.
- Demagnification – decreased image size compared to object size.

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Magnification Types

- **Size Magnification** = increase the relative object size.
- **Distance Magnification** = reduce object distance.
- **Angular Magnification** = magnifiers, binoculars, telescopes.
- **Digital Magnification** = computer monitors, digital tablet (size manipulation), over head projectors

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Linear Magnification

M = Image Distance / Object Distance

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Determine Lens Power and Linear Magnification

- f = focal length
- D = 100/f
- i = image height
- i_h = image distance
- o = object height
- o_h = object
- M = magnification

$1/f = 1/o_h + 1/i_h$

$M = i / o$

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Magnification

- An object is located is 10 cm in front of a convex lens.
- The Image is formed 40 cm behind the lens
- What is the lens dioptric power and linear magnification?

$1/ f = 1/o_h + 1/i_h$
$1/f = 1/10 + 1/40$
$1/f = 4/40 + 1/40$
$1/f = 5/40$
$1/f = 1/8$
$f = 8$ cm
100/8 = **+12.50 D lens**

M = i / o
M = 40 / 10
M = 4 x
Image size 4 times object size

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Implications of Magnification

- Binocular vision requires symmetrical retina image size
- Excessive magnification or demagnification distort images
  - + Plus Lenses (Pincushion distortion)
  - - Minus Lenses (Barrel distortion)

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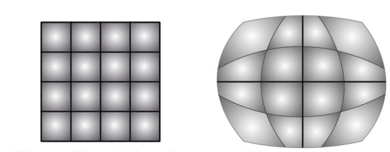
Aberration Barrel Distortion



Object without Distortion   Object with Barrel Distortion

Illustration excerpt: Pure Optics, Third Ed. 2023

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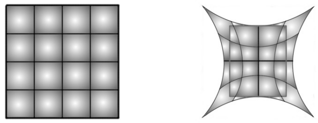
Aberration Pincushion Distortion



Object without Distortion

Object with Pincushion Distortion

Illustration excerpt: Pure Optics, Third Ed. 2023

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Design Factors

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Magnification Attributes

- Spectacle Lens Power (D_e)
- Base Curve (D_1)
- Vertex Distance (h_M)
- Refractive Index (n)
- Lens Thickness (t)

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Magnification Due to Lens Geometry

$SF = 1 / 1 – (t /n) (D_1)$

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Magnification Due to Lens Power

$PF = 1 / 1 – h_M (D_e)$

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Combining Lens Geometry and Power

$SF = 1 / 1 – (t /n) (D_1)$

$PF = 1 / 1 – h_M (D_e)$

SM in % = [(SF) (PF) - 1] (100)

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Example

A patient has a prescription and fitting parameters:

Single vision lenses, +4.00 DS, O.U.

The lenses are made from 1.60 n, 5 mm thick, vertex = 14 mm and a base curve of +8.00 D.

What is the percentage of spectacle magnification?

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Calculate Shape Factor

SF = 1 / 1 – (.005/ 1.60) (8)

SF = 1 / 1 – (.003) (8)

SF = 1 / 1 – .024

SF = 1 / .976

SF = 1.024

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Calculate Power Factor

PF = 1 / 1 – (h_M) (D_e)

PF = 1 / 1 – (.014) (+4.00)

PF = 1 / 1 - .056

PF = 1 / .944

PF = 1.059

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Multiply SF x PF

SM in % = [(SF) (PF) -1] 100

SM = [(1.024) (1.059) - 1] 100

SM = [1.084 - 1] 100

SM = 8%

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Example

What is the spectacle magnification in the 90th and 180th meridian of lens power:

OD -2.00 -1.00 x 180

- n = 1.50
- t = 1.5 mm
- vertex = 14 mm
- base curve = +6.00 D.

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Magnification Due to Lens Power

- Lens Geometry = Null
- SF Net Result = 0% delta
- Power Factor = total M%

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Magnification Due to Lens Power

$PF = 1 / 1 – h_M (D_e)$

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Variable Key

- Spectacle Lens Power (D_e)
- Vertex Distance (h_M)

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Calculate Power Factor x 090

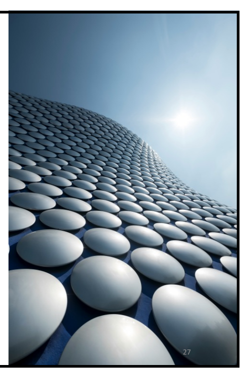
$PF = 1 / 1 – (h_M) (D_e)$

$PF = 1 / 1 – (.014) (-3.00)$

$PF = 1 / 1 - .042$

$PF = 1 / .958$

$PF = 1.043$



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Calculate Power Factor x 180

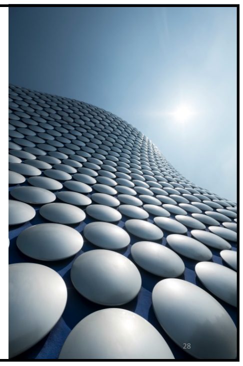
PF = 1 / 1 – (h_M) (D_e)

PF = 1 / 1 – (.014) (-2.00)

PF = 1 / 1 - .028

PF = 1 / .972

PF = 1.028



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Calculate Power Factor x 180

(PF @ 090 – PF @ 180) (100)

- 1.043 - 1.028
- (0.015) (100)
- **Delta = 1.5%**

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Lens Curvature

- Increasing the curvature of lens will decrease a lens' focal length
- Increasing the D_1 increases the magnification

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Example

What is the spectacle magnification of the following:
OD: Plano DS
OS: Plano DS

- n = 1.530
- t = 2.1 mm
- vertex = 12 mm
- base curve = +10.00 D.

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Magnification from Lens Power

- Lens Geometry = total M%
- Power Factor = Null

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Magnification Due to Lens Geometry

$$SF = 1 / 1 – (t /n) (D_1)$$

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Calculate Shape Factor

SF = 1 / 1 – (.003/ 1.530) (10)

SF = 1 / 1 – (.005) (10)

SF = 1 / 1 – .05

SF = 1 / .95

SF = 1.05

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Magnification Needed for Afocal Size Lenses

$$Mt = -t (D_2) / 10n$$

Mt = Total magnification needed
-t = Thickness
D_2 = Ocular curve
n = Substrates refractive index

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Iseikonic Lens Designs

- Iseikonic lenses are design to balance the magnification between the right and left pair of spectacle lenses.
- Multiple methods to balance magnification symmetry can be used using advanced digital computer lens modeling software, analog calculations, and nomographs.

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Contacts and Magnification Truth vs. Myth

- **Contact Lenses** - effective only for anisometropia less than 4.00 D. and K readings are **not the same**.
- Works for **refractive** vs. axial ametropia's.

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Analog 20/20 Method

1. Multiply the stronger lens' base curve and thickness by 20%.
2. Use the product of this calculation for the opposing lens.

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Analog 20/20 Method

OD:+5.00 DS (t = 8.25 mm, BC +10.00 D)

OS:+2.00 DS (t = 5.10 mm), BC +8.25 D)

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Analog 20/20 Method

Existing Parameters

OD:+5.00 DS (t = 8.25 mm, BC +10.00 D)
OS: +2.00 DS (t = 5.10 mm, BC +8.25 D)

New Parameters

OD:+5.00 DS (t = 8.25 mm, BC +10.00 D)
OS: +2.00 DS (t = 9.90 mm, BC +12.00 D)

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OS Shape Factor

SF = 1 / 1 – (t /n) (D_1)

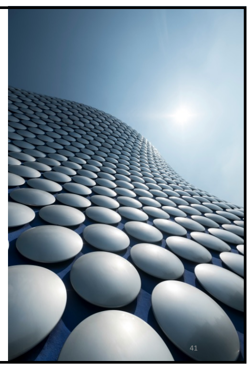
SF = 1 / 1 – (.00990/ 1.498) (12.00)

SF = 1 / 1 – (.0066) (12.00)

SF = 1 / 1 – .0792

SF = 1 / .9208

SF = 1.0860



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OS Power Factor

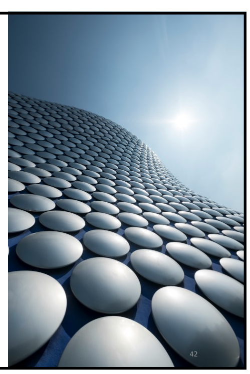
PF = 1 / 1 – (h_M) (D_e)

PF = 1 / 1 – (.013) (+2.00)

PF = 1 / 1 - .026

PF = 1 / .9740

PF = 1.0266



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Calculate Total Magnification

SM in % = [(SF) (PF) -1] 100

SM = [(1.0860) (1.0266) - 1] 100

SM = [1.11 - 1] 100

SM = 11%

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Analog 20/20 Method

Lens	SM Non-Iseikonic	SM Iseikonic
OD	13.30%	13.30%
OS	6.04%	11.43%
Delta	**7.26%**	**2.13%**

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Avoid Standardized BC Charts

OD: +1.25 DS
OS: +3.50 DS

- Lenses 1.498_n
- Vertex 12 mm

72 mm Finished Blank

OD = 6 BC, 3.1 mm ct.
OS = 8 BC, 5.9 mm ct.

Net Magnification

OD = 2.79% X
OS = 7.79% X

Delta = 5% X

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Influencing Magnification	
Increase the base curve (steeper)	Increases magnification
Increase center thickness	Increases magnification
Increase vertex for hyperopes	Increases magnification
Decrease for myopes	Increases magnification
Balancing Spectacle Magnification	
Hyperopes	Change vertex and thickness Vs. base curve
Myopes	Change base curve and vertex Vs. thickness

Source: Excerpt from, Pure Optics Third Edition 2023 textbook

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Questions

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